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METHODS OF TEST FOR RESISTANCE OF METALLIC ELECTRICAL RESISTANCE MATERIAL

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Indian Standard

METHODS OF TEST FOR RESISTANCE OF METALLIC ELECTRICAL RESISTANCE MATERIAL

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 13 June 1966, after the draft finalized by the Electrical Instruments and Meters Sectional Committee had been approved by the Eletrotechnical Division Council.

0.2 This standard prescribes methods to be used in determining resistance of metallic electrical resistance material in referee and routine tests. The accuracy specified in the referee method is what could be achieved under laboratory conditions. Routine tests, of course, do not aim at the same degree of precision as referee tests, but they would be found to be sufficient for most practical cases. In case of dispute, referee method should be used.

0.3 The electrical resistivity may be calculated from a knowledge of resistance and dimensions of test specimen (*see* **4**) but generally in practice it is not required to know the resistivity of the resistance material to the same order of accuracy as resistance per unit length.

0.4 In the preparation of this standard, assistance has been derived from B.S. 3466 : 1962 'Methods of test for resistance per unit length of metallic electrical resistance material' issued by the British Standards Institution.

0.5 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard describes a referee method and a routine method of determining the electrical resistance per unit length of metallic electrical resistance material. The referee method provides for an overall accuracy of 0·2 percent and the routine method provides for an overall accuracy of 1 percent in resistance per unit length on test specimens having a resistance of 1 milliohm or more.

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*Rules for rounding off numerical values (*revised*).

2. REFEREE METHOD

2.1 Test Specimen

2.1.1 The test specimen shall have the following characteristics:

a) No joints or splices,

b) A test length of at least 30 cm, and

c) A resistance of at least 1 milliohm in the test length between potential contacts.

2.2 Apparatus

2.2.1 Where the resistance of the test specimen is below 10 ohms, the resistance shall be measured with a Kelvin double bridge or with a potentiometer. Where the resistance is 10 ohms or more, a Wheatstone bridge may be used.

2.3 Procedure

2.3.1 The resistance test length shall be sufficiently well defined to permit its determination with an accuracy of at least 0·05 percent.

2.3.1.1 When a Kelvin double bridge or a potentiometer is used, the potential contacts shall be substantially sharp needle points or knife-edges. On flat surfaces needle points are, in general, preferable. The test length shall be determined either from the known distance between the potential contacts or by measuring the distance between the marks left on the specimen by the potential contacts.

2.3.1.2 The test specimen shall not be under appreciable strain during the determination of resistance.

2.3.2 Where potential leads are used, the distance between each potential contact and the corresponding current contact shall be at least equal to 1·5 times the cross-sectional perimeter of the specimen. Where the double-bridge method is used, the yoke resistance, between reference standard and test specimen, shall be appreciably smaller than that of either the reference standard or the test specimen, unless a suitable lead compensation method is used, or it is known that the coil and lead ratios are sufficiently balanced so that variation in yoke resistance will not decrease the bridge accuracy below requirement.

2.3.3 The specimen shall be subjected to a temperature of 140° ± 5°C for not less than 16 hours for alloys of the 80/20 nickel/chromium type and of the copper/manganese type with an approximate composition 84/12, and to a baking period specified by the manufacturer for other alloys. The purpose of this treatment is to stabilize the resistance of the wire, and the measured characteristics of the specimen after treatment shall be considered as the true resistance characteristics of the material.

2.3.4 Resistance measurements shall be made to an accuracy of 0·1 percent and the specimen shall be immersed in oil while the measurement is made.

2.3.4.1 If the temperature coefficient of resistance of the material under test does not exceed 500 ppm per deg C, the temperature of the oil shall be measured with a thermometer which is accurate to 0·5 deg C.

2.3.4.2 If the temperature coefficient of resistance of the material under test is greater than 500 ppm per deg C, the temperature of the oil shall be measured with a thermometer which is accurate to 0·1 deg C, and the temperature of the oil with the specimen immersed shall be measured at least twice, with an interval of not less than 15 minutes between measurements. The last temperature reading shall be taken immediately before making the resistance measurement and shall not vary from the preceding reading by more than 0·1 deg C. This temperature shall be recorded.

2.3.5 The test current shall not be of such a magnitude as to produce an appreciable change in resistance of the specimen or measuring apparatus due to the heating effect.

2.3.5.1 To determine experimentally that the test current is not too large, the specimen may be immersed in a bath at 27° ± 1°C. The test current is applied and maintained until the resistance of the specimen has become constant. The current is then increased in steps up to 140 percent of its initial value, and the resistance is measured at each step. If the resistance at any step differs from the original value by more than 0·02 percent, the test current is too large and should be reduced until the foregoing limitation is reached.

2.3.6 The measurements shall be made in such a way that the effects of thermoelectromotive forces and parasitic currents are minimized.

2.3.6.1 Thus, in a bridge circuit, if there is appreciable thermoelectromotive force, it may be desirable to close the galvanometer key first. If the galvanometer deflects, it is allowed to reach a steady deflection, and balance is regarded as having been achieved if there is no further movement of the galvanometer when the battery key is closed. If however, there is appreciable inductance in the circuit there may be a transient deflection when the battery key is closed, and it is then sometimes better to close the battery key first. The bridge is adjusted until there is no deflection when the galvanometer key is closed, but since the balance may be affected by thermoelectric effects, it is necessary to take another reading with the battery connections reversed. The resistance of the specimen is taken as the mean of the two readings.

2.3.6.2 If a potentiometer method is used, the specimen under test and a high quality resistance standard are connected in series to a steady and adjustable source of direct current, and the potentiometer is switched alternately to the standard and the specimen. It is unnecessary to standardize the potentiometer against a standard cell, the potentiometer current and/or the current through the specimen may be adjusted so that when connected to the standard the potentiometer balances at some convenient round figure, S, such as 1·000 00. The potentiometer is then quickly switched to the specimen and the reading, R is taken at balance. The resistance of the specimen is given by

$$\frac{R}{S} \times \text{resistance of standard}$$

In order to eliminate the effect of thermoelectromotive force, it is desirable to repeat the procedure with both potentiometer current and specimen current reversed. The resistance of the specimen is taken as the mean of the two results.

2.4 Temperature — The temperature at which measurements are carried out shall be 27° ± 1°C and shall be recorded. No correction shall be made for departure from 27°C.

2.5 Consistency of Testing — Three specimens cut from a sample approximately four times the length of one specimen shall be tested and the resistance per unit length of each shall be calculated. The mean of the three results shall be taken as the resistance per unit length of the sample. If the highest value differs from the lowest by more than 0·1 percent of the mean, the test shall be regarded as invalid and shall be repeated on new specimens.

3. ROUTINE METHOD

3.1 Test Specimen

3.1.1 The test specimen shall have the following characteristics:

a) No joints or splices,

b) A test length of at least 30 cm, and

c) A resistance of at least 1 milliohm in the test length between potential contacts.

3.2 Apparatus — Where the resistance of the test specimen is below 1 ohm, the resistance shall be measured with a Kelvin double bridge or with a potentiometer; where the resistance is 1 ohm or more, a Wheatstone bridge may be used.

3.3 Procedure

3.3.1 The resistance test length shall be sufficiently well defined to permit its determination with an accuracy of at least 0·2 percent

3.3.1.1 When a Kelvin double bridge or a potentiometer is used, the potential contacts shall be substantially sharp needle points or knife-edges. On flat surfaces needle points are, in general, preferable. The test length shall be determined either from the known distance between the potential contacts or by measuring the distance between the marks left on the specimen by the potential contacts.

3.3.1.2 The test specimen shall not be under appreciable strain during the determination of resistance.

3.3.2 Where potential leads are used, the distance between each potential contact and the corresponding current contacts shall be at least equal to 1·5 times the cross-sectional perimeter of the specimen. Where the double bridge method is used, the yoke resistance, between reference standard and test specimen, shall be appreciably smaller than that of either the reference standard or the test specimen, unless a suitable lead compensation method is used, or it is known that the coil and lead ratios are sufficiently balanced so that variation in yoke resistance will not decrease the bridge accuracy below requirement.

3.3.3 Resistance measurements shall be made to an accuracy of 0·2 percent. The temperature of the surrounding air shall be measured with a thermometer, which is accurate to 0·5 deg C, placed as close to the specimen as possible. If the test specimen has been kept under temperature conditions different from the room temperature at the testing position, it shall be allowed to come to the same temperature as the surrounding air before the commencement of the test. In all resistance measurements, the measuring current tends to raise the temperature of the specimen above that of the surrounding medium. Therefore, care shall be taken to keep the magnitude of the current low. To eliminate errors due to thermoelectromotive forces two readings, with current reversed, shall be taken in rapid succession, and the mean value calculated.

3.4 Temperature — The temperature at which measurements are carried out shall be 27° ± 1°C and shall be recorded. No correction shall be made for departure from 27°C.

4. RESISTIVITY

4.1 Resistivity, that is, the volume resistivity is the resistance per unit length of a conductor of uniform cross-section having unit cross-sectional area, if required (*see* **0.2**) it may be calculated by the following formula:

$$\rho = \frac{A}{L} . R$$

where

ρ = resistivity,
A = cross-sectional area,
L = length, and
R = resistance.

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